Redefining MRI:
From Image to Insight

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Meet the New Experts

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Lung MRI

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The lung is among the more challenging organs to image with MRI. Because the parenchyma consists largely of air, it has low proton density, and field inhomogeneity at the numerous air–tissue interfaces causes the signal to decay within a very short time (short T2*); cardiac and respiratory motion further complicate imaging. For these reasons, CT has been the standard for thoracic imaging, but it involves ionizing radiation and primarily provides static structural images at end-respiratory phases.

In the assessment of lung disease, information on ventilation function—where air travels, how much, and how quickly—is also important, in addition to structure. Techniques such as hyperpolarized-gas MRI can image this function but are limited in clinical use by the need for specialized equipment and gas agents. This talk introduces our work using ultrashort echo-time (UTE) MRI, which acquires data before the signal decays, to image lung ventilation without gas or contrast agents and to apply it to phenotypic assessment of chronic obstructive pulmonary disease (COPD).

From free-breathing 3D UTE acquisitions with retrospective respiratory gating into six phases, we derive two complementary metrics: the ventilation-weighted (VW) map, reflecting static regional air-volume change, and the ventilation flow capacity–weighted (VFCW) map, capturing the dynamic rate of ventilation change across the respiratory cycle. In nine healthy volunteers, VW maps showed strong spatial agreement with SPECT, and the two metrics responded differentially to breathing conditions, indicating that VFCW reflects the dynamic characteristics of ventilation rather than static volume alone.

We then examined phenotype-specific relevance in COPD. In a prospective feasibility study, 21 patients were classified by the presence (BD, n=12) or absence (NBD, n=9) of bronchial disease on CT. In the BD group, VFCW showed strong positive correlations with FEF25–75% predicted ($r=0.84$, $P<.001$), FEV1 ($r=0.74$, $P=.006$), and FEV1/FVC ($r=0.72$, $P=.008$), whereas in the NBD group these associations were absent or inverse. Absolute VW and VFCW values did not differ between groups ($P=.46$ and $.59$).

These findings suggest that the same ventilation metric may carry different physiological meaning depending on the underlying disease pattern, with VFCW showing potential as a non-invasive, spatially informative indicator of airway-related airflow limitation. Radiation-free 3D UTE ventilation mapping may thus complement spirometry and CT in phenotyping obstructive lung disease.

Keywords: *Lung MRI, Ultrashort echo-time, Ventilation, Pulmonary function image*